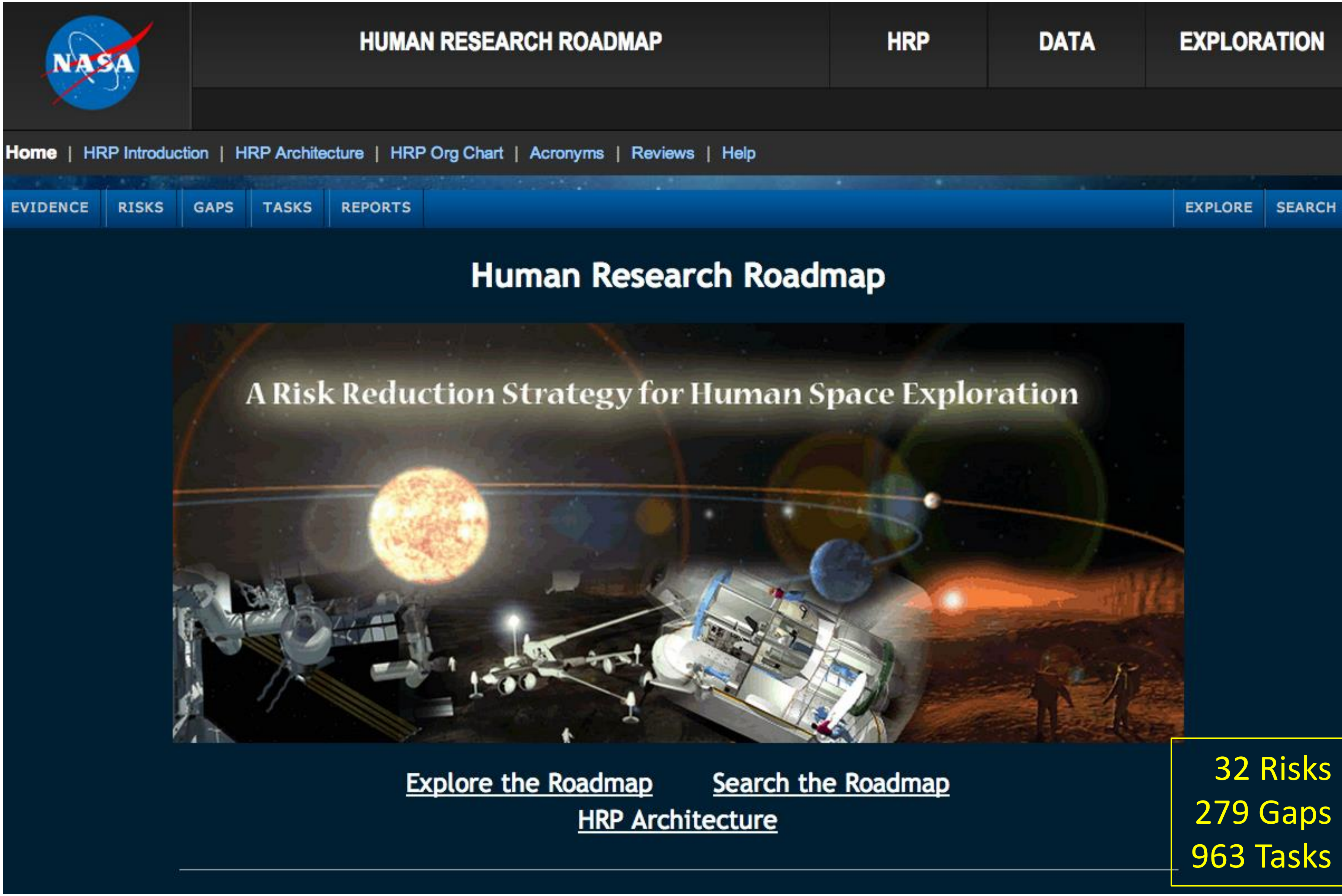
Session 6: Panel Discussion

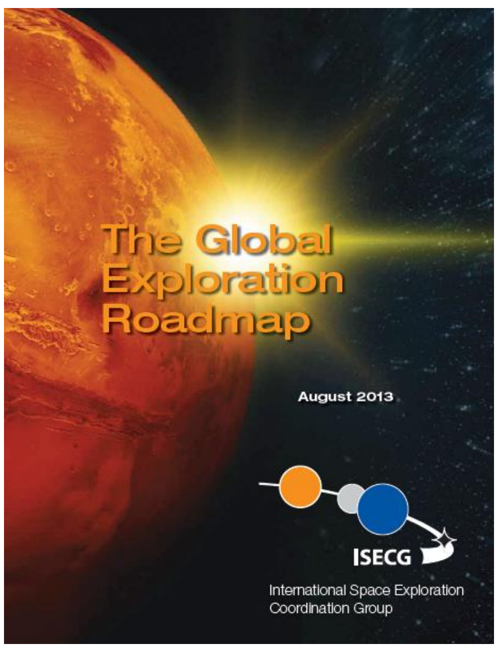
- **Vincenzo Giorgio**
  — TASI, Thales Alenia Space
- **Craig Kundrot**
  — NASA, Lyndon B. Johnson Space Center
- **Les Johnson**
  — NASA, George C. Marshall Space Flight Center
- **Steve Hoffman**
  — Science Applications International Corporation
- **Sam Scimemi**
  — NASA, Headquarters



32 Risks
279 Gaps
963 Tasks

humanresearchroadmap.nasa.gov

In Space Transportation Technologies Supporting the Global Exploration Roadmap

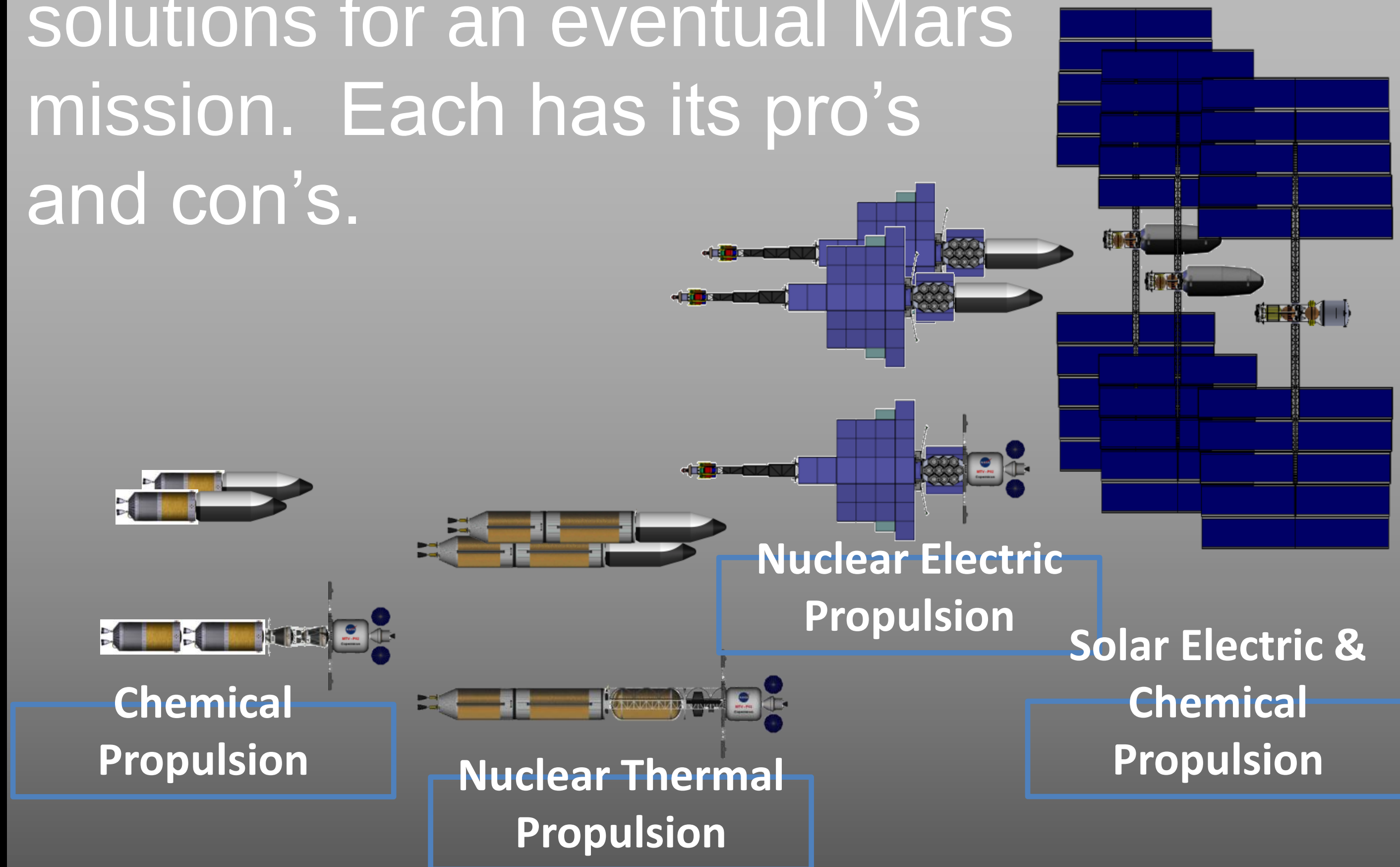


Les Johnson

(NASA George C. Marshall Space Flight Center)

Sending People To Mars – It's All About Mass

There are many technical solutions for an eventual Mars mission. Each has its pro's and con's.



The technologies we develop for today's missions will narrow our options for tomorrow's.

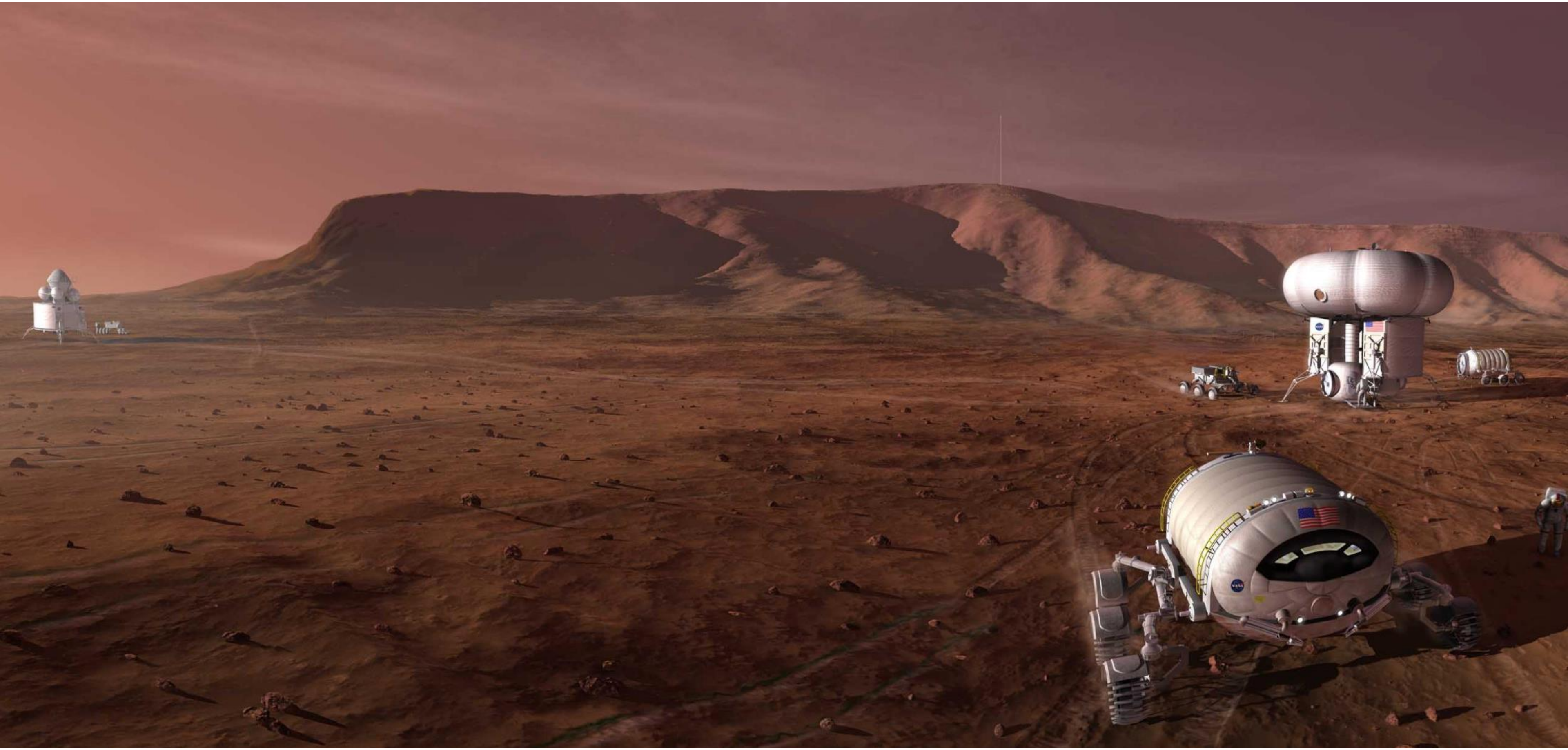
Human Exploration Preparatory Activities from the GER

Critical Technology Needs by Technology Area[2]

In-Space Propulsion Technologies (TA02)	Life Support & Habitation Systems (TA06)
• Liquid Oxygen/Methane Cryogenic Propulsion System (Mars Lander) • Advanced In-Space Cryogenic Propellant Storage & Liquid Acquisition • Electric Propulsion & Power Processing • Nuclear Thermal Propulsion (NTP) Engine	• Closed-Loop & High Reliability Life Support Systems • Fire Prevention, Detection & Suppression (reduced Pressure) • EVA Deep Space Suits, including lunar & Mars environment • Advanced EVA Mobility (Suit Port)
Space Power & Energy Storage (TA03)	**Long Duration Human Health (TA06)**
• High Strength & Autonomously Deployable In-Space Solar Arrays • Fission Power for Electric Propulsion & Surface Missions • Regenerative Fuel Cells • High Specific Energy & Long Life Batteries	• Space Flight Medical Care, Behavioral Health & Performance • Microgravity Biomedical Countermeasures • Human Factors & Habitability • Space Radiation Protection/Shielding

Human Exploration of Mars Task Opportunities

National Aeronautics
and Space Administration

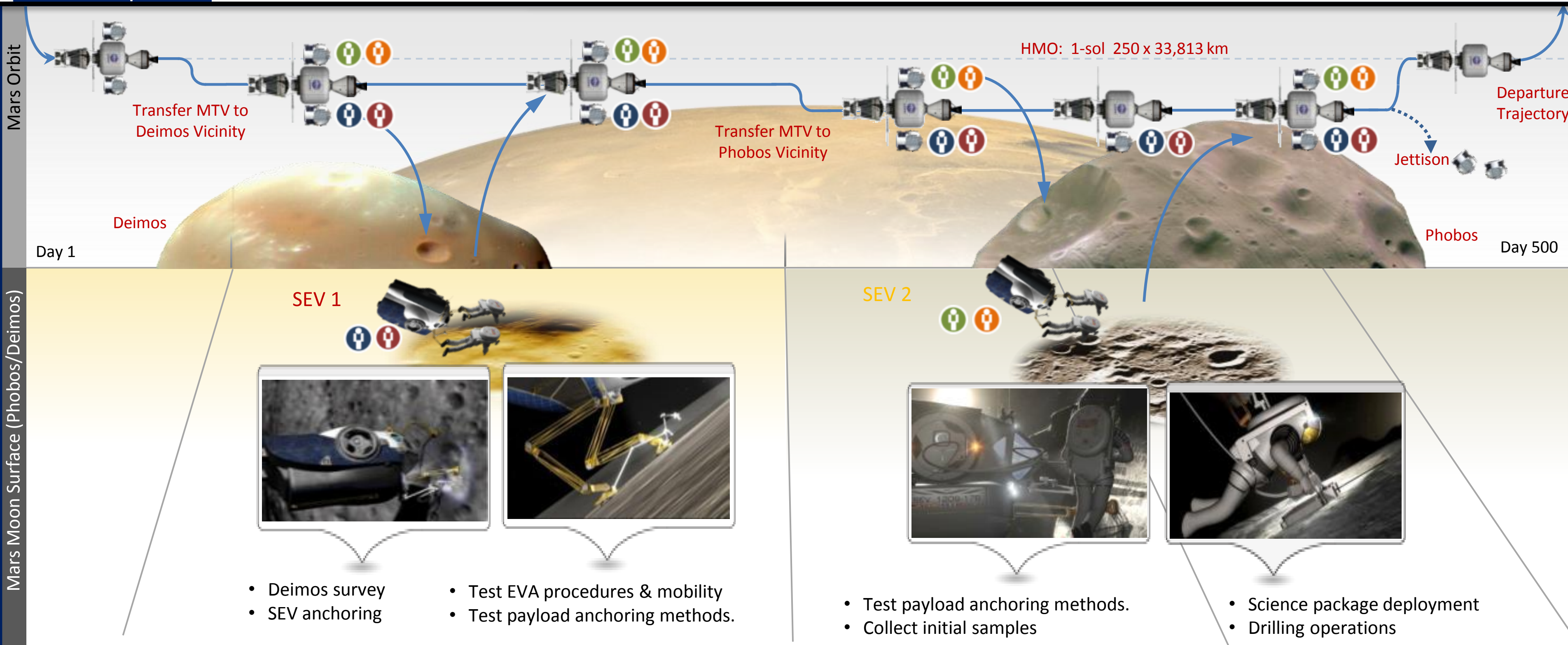


Stephen J. Hoffman, Ph.D.
Science Applications International Corporation

April 2014

Long-Stay Mars Orbital Operations

Mission Sequence



Mission Summary

Assumed Mars Orbit Strategy

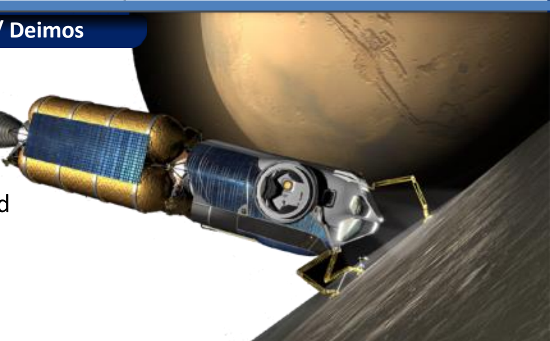
1. Capture into a 1-sol parking orbit with proper plane change to Deimos inclination
2. Lower Mars Transfer Vehicle to Deimos orbit (767 m/s delta-v required)
3. Prepare for orbital operations
4. Utilize SEV-1 to explore Deimos numerous times
5. Lower Mars Transfer Vehicle to Phobos orbit (816 m/s delta-v reqd.)
6. Utilize SEV-2 to explore Phobos numerous times
7. Raise to 1-sol parking orbit (planar) (796 m/s)
8. Trans-Earth Injection including plane change

Mission Site: Phobos / Deimos

Crew: 4

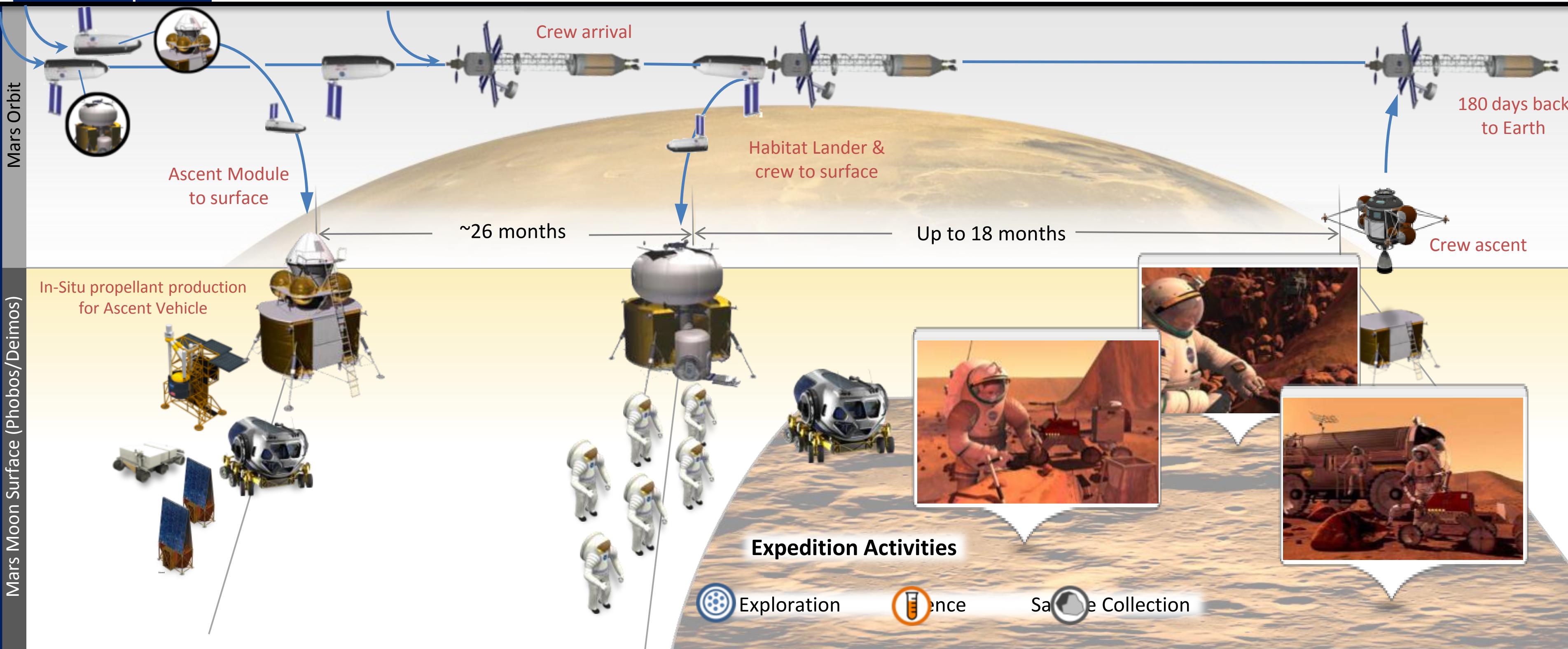
Deimos:
20,063 km circular
0.9 deg, 1.26 day period

Phobos:
5981 km circular
1 deg, 0.32 day period



Mars Surface Operations

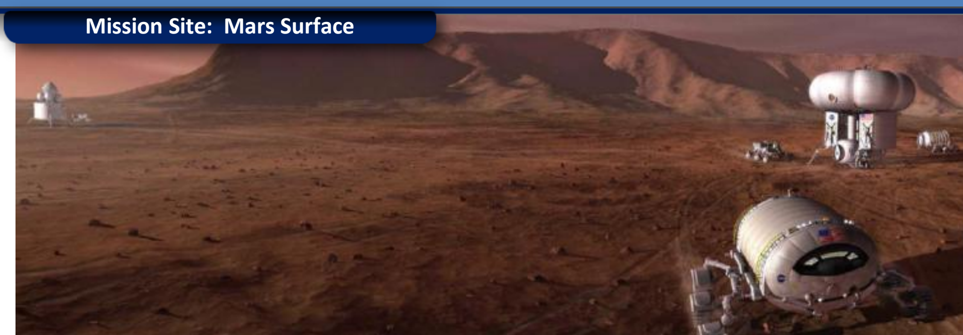
Mission Sequence



Mission Summary

- Long surface stays with visits to multiple sites provides scientific diversity
- Sustainability objectives favor return missions to a single site (objectives lend themselves best to repeated visits to a specific site on Mars)
- Mobility at great distances (100s kilometers) from the landing site enhances science return (diversity)
- Subsurface access of 100s meters or more highly desired
- Advanced laboratory and sample assessment capabilities necessary for high-grading samples for return

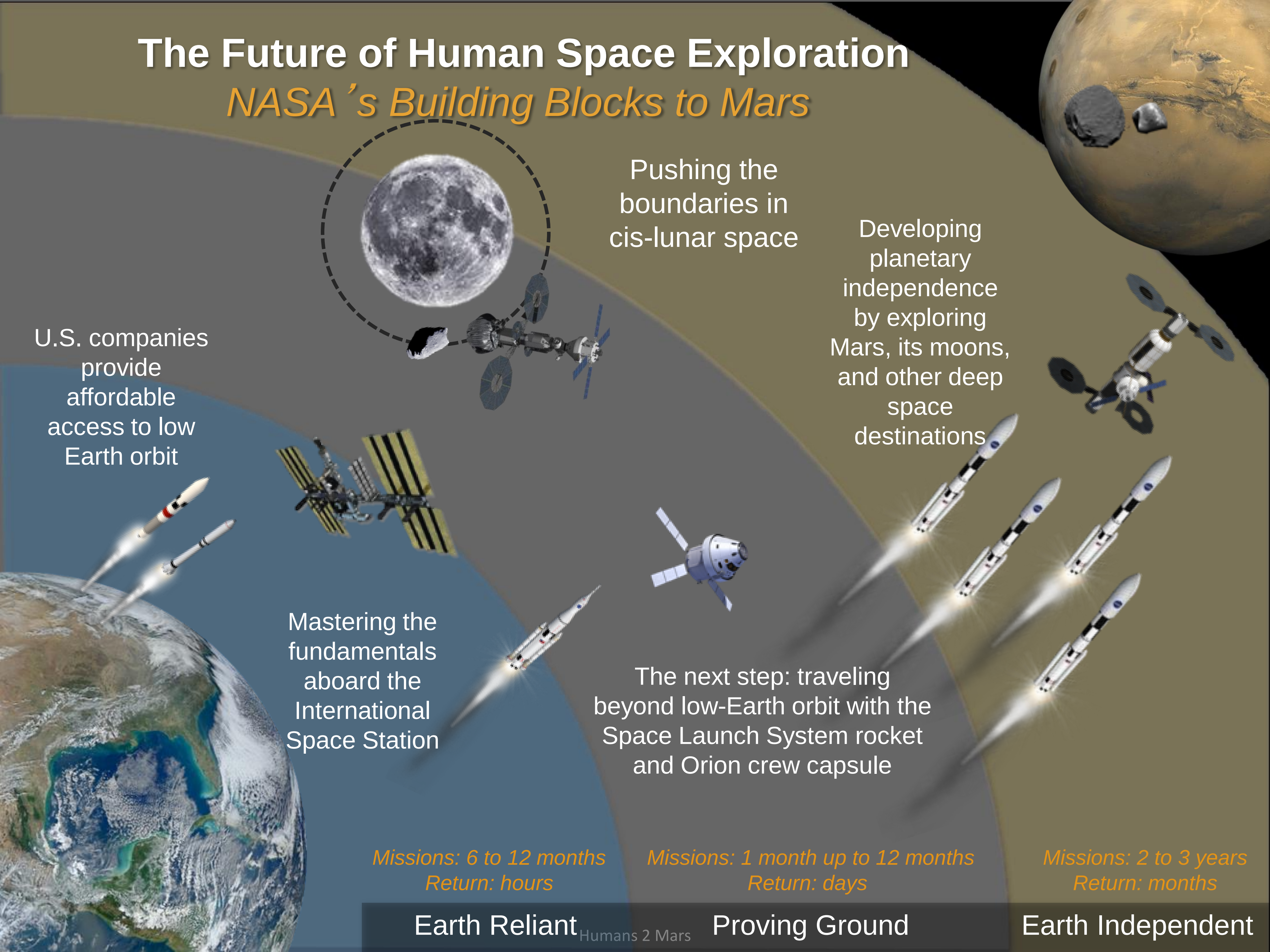
Mission Site: Mars Surface



The International Space Station and the Road to Mars

Sam Scimemi
Director, International Space Station
NASA Headquarters

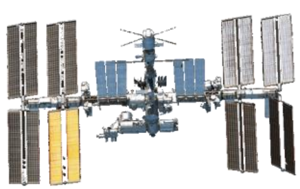
NASA Community Workshop on GER
11 April 2014
JHU Applied Physic Laboratory


The Future of Human Space Exploration
NASA's Building Blocks to Mars
U.S. companies provide affordable access to low Earth orbit
Mastering the fundamentals aboard the International Space Station
Pushing the boundaries in cis-lunar space
The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion crew capsule
Developing planetary independence by exploring Mars, its moons, and other deep space destinations
Missions: 6 to 12 months
Return: hours
Missions: 1 month up to 12 months
Return: days
Missions: 2 to 3 years
Return: months
Earth Reliant
Humans 2 Mars
Proving Ground
Earth Independent

Filling in the Gap

Today – 2020's — 2020's — 2030's

ISS
400 kilometers



- 6 month crew duration
- Crew health and performance research not complete
- Habitation and life support systems are large and require regular maintenance
- Regular resupply, return and trash removal
- Ground analysis of crew and environmental samples
- Near real-time communications
- Crew return in hours

Car camping in space

Mars
228,000,000 kilometers

- 2-3 years crew duration in free space
- Crew, habitation and life support systems have no resupply
- No ground validation of crew/environmental samples
- Communication delay of up to 42 minutes
- Crew return in months

Independent life